National Bureau of Standards

March 1956
Volume 40
Number 3

Technical News Bulletin

MAR 23 1956

Interconnection of Electronic Computors

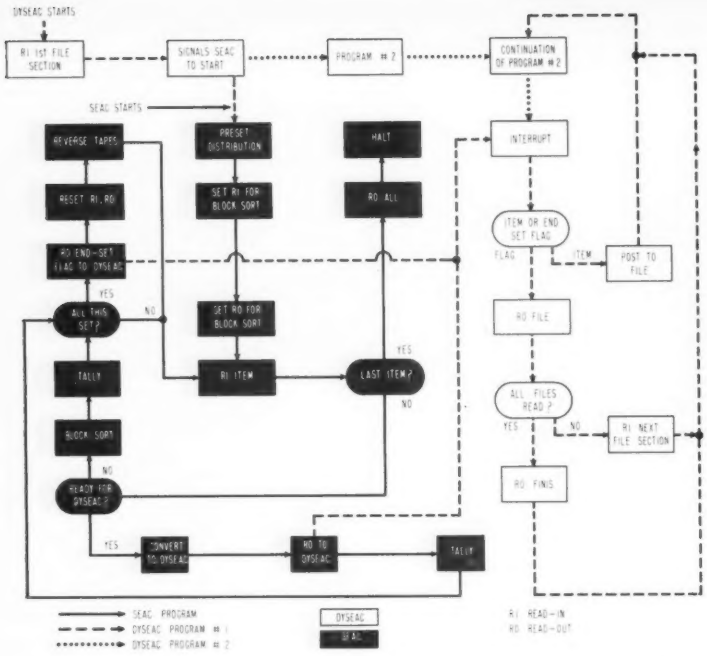
One machine controls other, sharing single problem

DATA-PROCESSING shared by two interconnected electronic digital computers has been successfully performed at the National Bureau of Standards. SEAC and DYSEAC,[1] two high-speed computers designed and built at the Bureau, worked cooperatively on a common task to demonstrate program-controlled machine intercommunication in which coordinated programs were read into both machines. The problem simulated a situation where stock transaction reports are tabulated and summarized for fiscal accounting, and then forwarded for posting to inventory control records elsewhere. The experiments were carried out by the Bureau's data processing systems laboratory as part of a cooperative program with the Navy Bureau of Supplies and Accounts to investigate the application of electronic techniques to the problems of supply management. The experiments showed that two digital computers need not have identical operating characteristics to work together, provided that one of them has the necessary control flexibility.

Typical applications of digital computers as data processors involve replacement of many small specialized machines by a single automatic system. However, for massive paper-handling operations, or for large-scale activities requiring the processing of the same data for different purposes at different locations, the use of more than one high-speed data processor may be necessary. For instance, in the farflung supply organizations of the armed services, expediting flow of information is essential to efficient supply management. Automatic communication between machines has been foreshadowed by direct input and output provisions so that the computer continues with other useful work while transfers of information between it and external devices are in process, and by tape-processing devices where search is under the program control of a computer. In this example, however, the interconnection is between a computer serving as the nucleus of a processing system and other parts of the same system.

Most general-purpose electronic computers employ a generally compatible digital language, can receive and transmit data in the form of electrical signals via standard communication channels over any desired distance, and can alter the course of processing programs in accordance with new or revised information. It should therefore be possible to interconnect two or more general-purpose machines so that they can cooperate on a common task. For example, a versatile large-capacity data-processor at a materiel control center might receive data fed to it automatically by smaller computers located at various supply depots. The supervisory processor (at the center) might so control the systemwide processing that it would accept data from each of its reporting sources in a scheduled sequence but would also be free to accept and handle priority requests for supply action from any of the depots at any time.

374769—56



Flow diagram of problem shared by the interconnected computers, SEAC and DYSEAC. In this problem, stock transaction reports are tabulated and summarized by SEAC, then forwarded to DYSEAC for posting. Results of the experiment demonstrate clearly the ability of DYSEAC to respond to monitor signals originating in SEAC and to interrupt its program in order to receive and process the detail data from SEAC. DYSEAC worked on an independent sequence of typical machine operations, simulating a concurrent program, while waiting for SEAC to transmit data.

For the kind of interaction where both information and exchanges of control are transferred between computers, the question of programed control versus automatic interruption is particularly important. Programed control depends to a considerable extent on human anticipation of when and how the interchanges should occur; however, if two or more systems are to interact automatically without human intervention, provision must be made for automatic interruption of a program in process in order to turn to the new information just received from another system. DYSEAC provides such interruption properties.

DYSEAC was designed for the Department of Defense to serve as the nucleus of a generalized feedback control network. This computer incorporated a number of operating features enabling it to respond automatically to information from remote external devices. These operating features include manual-monitor facilities, program-control flexibility, and special input-output controls. Together they provide DYSEAC with unusual properties of concurrent operation, self-regulation, and interruptibility which enable it to interact effectively with another computer.

During a period of 3 weeks the two machines, SEAC and DYSEAC, were available for experiments in interconnection. The program chosen for the experiment was a new method of sorting, merging, and posting of records. In the problem, stock transaction reports were tabulated and summarized by SEAC, then forwarded to DYSEAC for posting. In the SEAC program for running this problem, as detail items were identified as belonging to each file section in a scheduled order, they were transferred to DYSEAC for posting there. In addition, after each complete set of detail items for a particular file section had been processed, SEAC transmitted a special end-of-set flag to DYSEAC. The coordinated DYSEAC program called for (1) responding to the SEAC transmitted signal, (2) reading-in the message from SEAC, (3) determining whether the message was a detail item or an end-of-set flag, and (4) either tallying the appropriate master file item in the first case, or reading out one file section and reading in the next in the case of the flag.

A cable between the SEAC building and the trailer van housing DYSEAC provided interconnection through a regular input-output terminal of each machine. Information transfers were initiated and terminated by transmission of control signals between the two machines. Whenever a SEAC output instruction called for selection of the particular output used for transmission to DYSEAC, a 62-volt preparatory signal was sent from the SEAC external selector unit to DYSEAC. This signal activated appropriate monitor operations in DYSEAC. As soon as DYSEAC was ready to accept the data, it transmitted a 62-volt signal to SEAC. Only upon receipt of this signal was SEAC able to proceed with its next instruction. In effect, SEAC continued trying to complete this output instruction until DYSEAC signaled readiness to accept the transfer.

This dual machine interconnection utilized both the special program control and the manual-monitor features of DYSEAC. In terms of program control, DYSEAC is a three-address automatically sequenced machine; choice between 1 of 2 counters as the source of the address of the actual next instruction is determined by control-code digits in the instruction being executed at any operation time. In addition, a special

address-storage register can serve to locate the next instruction when new information or new instructions are to be interpolated into a program that is being processed, as in the case of manual-monitor operations.

Manual-monitor operations are those that are carried out by the machine when certain prespecified conditions arise in the course of the machine's internal program and simultaneously in external switch settings. The switch settings are controlled either by the machine operator or by d-c voltage signals originating in external devices at any distance from DYSEAC. Thus, the machine can monitor its internal program to determine precisely when special operations requested by an external source are to be performed.

If the switch settings that are controlled by d-c voltages from the external device indicate that the device is ready, DYSEAC will then carry out the indicated operation, such as direct loading of one or more memory locations, and select its next instruction from the location specified by the address-storage register. The next instruction selected in this manner then indicates in its program-control digits which of the two counters is to be used next. In this way, it can either return DYSEAC to a program that had been discontinued during the interruption or initiate an entirely new sequence.

For the DYSEAC-SEAC interconnection, monitor switch settings were arranged so that upon receipt of the preparatory signal from SEAC, DYSEAC at its next breakpoint read in one information word to a predetermined memory address and took its next instruction from the location indicated in the address-storage register. This next instruction was a "file" order which recorded both counter settings, reset the proper counter to the initiation of the routine for the processing of the data from SEAC, and transferred control to that counter. Upon completion of the processing of any one set of data from SEAC, DYSEAC would return to the sequence of operations it had been performing immediately prior to each interruption.

When the coordinated programs had been read into both machines, SEAC was set to run but was inhibited by a control signal from DYSEAC. When DYSEAC had completed reading in the first file section and had proceeded to other independent operations, a release of control enabled SEAC to start. As soon as the SEAC-processed data were ready for posting, they were converted to the proper format for DYSEAC, transmitted, and checked by DYSEAC to see whether there had been garbling in transmission. The receipt of data simulating a detail item resulted in a tally count for the appropriate master item in the file section.

Several runs of the shared program were successfully made, and the "posted" file sections were printed out on a DYSEAC magnetic wire cartridge. These results clearly demonstrated the ability of DYSEAC to respond to the monitor signals originating in SEAC and to interrupt its program in order to receive and process the detail data from SEAC. The two machines were thus made to work cooperatively on the common task that involved preliminary processing of data by SEAC, transmission of these data and program information from SEAC to DYSEAC, and further processing by DYSEAC. DYSEAC worked on an independent sequence of typical machine operations, simulating a concurrent program, during the intervals in which it waited for SEAC to transmit data.

Only a limited form of master-slave relationship was demonstrated. Only one of the two machines, DYSEAC, had the flexible system design features that provide for multiple program processing and interruptibility necessary in the interdependent system. However, this limited experiment did demonstrate the significant fact that two machines need not have identical capabilities and characteristics in order to share a common data-processing program, provided that one machine has the necessary flexibility. The one machine that is capable of multiple-program processing with interruptibility can receive and process data fed directly to it from one or more external sources and can therefore share its high-speed memory, computing ability, and output facilities with remotely located external devices, including other computers with different characteristics.

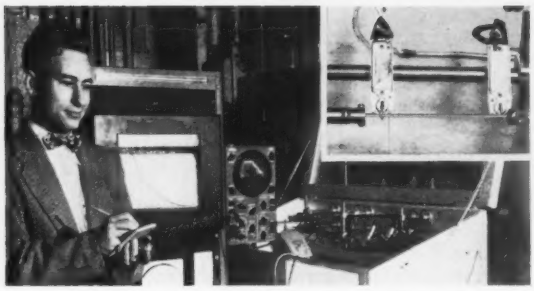
[1] *SEAC, completed in 1950, is a permanent installation at NBS. DYSEAC, a mobile installation, has been delivered to the Army Signal Corps for a special application. For further technical information, see* The interconnection of two digital computers, *M. E. Stevens, AIEE Conference Paper CP No. 55-736 (1955)*; DYSEAC, the new NBS electronic computer, *NBS Tech. News Bull.* **38**, *134 (Sept. 1954)*; SEAC, the NBS electronic automatic computer, *Tech. News Bull.* **34**, *121 (Sept. 1950)*; Computer Development (SEAC and DYSEAC) at the National Bureau of Standards, Washington, D. C., *Circular 551, available at the Government Printing Office, Washington, D. C. for $2.00.*

A Sonic Technique for Testing Leather

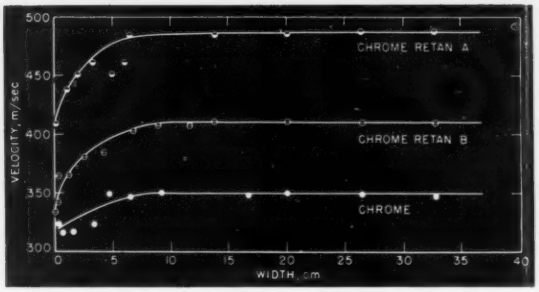
A NONDESTRUCTIVE method for testing leather, based on the transmission of sound waves, has recently been developed. The chief instrument employed is a pulse propagation meter which measures and records the speed of a generated sound pulse through the leather. As a result, the specimen under test is left unharmed, in contrast to the tearing or other destructive effects of existing test procedures.

The experiments [1] have shown that the velocity of sound transmission in leather varies substantially with changes in chemical and physical structure and, particularly, in fiber orientation. Velocity measurements, accordingly, are indicative of modifications of the fibrous order produced by strain, aging, and impregnating material. The study was sponsored by the Army's Office of the Quartermaster General and was conducted by Joseph R. Kanagy and Myron Robinson of the leather laboratory.

In recent years the use of sonic techniques to determine certain mechanical properties of high polymers has become widespread. Such methods have employed frequencies ranging from less than 1 cps up to several megacycles per second. The use of a single frequency throughout a series of tests readily permits



The equipment above is used for the nondestructive testing of leather by means of sound waves. The leather specimen is in box at right. Inset shows a closer view of specimen and position of transmitting and receiving crystals used to propagate sound.



Graph shows how sound velocity depends on width in sonic test of leather. Bottom curve is for specimen tanned with chrome alone. Top two specimens from different sources were tanned with chrome and retanned with vegetable tannins. Velocity increases with width. This is due to random arrangement of fibers, causing sound to travel along irregular path.

mathematical analysis of the data and determination of the physical constants characteristic of the viscoelastic behavior of the material. Besides furnishing a means for securing fundamental information, sonic methods have been successfully utilized in nondestructive testing. These applications relate mainly to the location of flaws in a variety of manufactured products.

The investigations of the leather laboratory are part of a larger program of fundamental and applied research on natural and synthetic polymers—rubber, plastics, textiles, leathers, and papers. This program seeks not only to improve present basic knowledge of high polymers but also to make possible their more effective utilization in commercial products. The present study of the potentialities of sound-transmission measurements is expected to provide the basis for improved methods of testing finished products like military footwear as well as the unworked hide.

The Bureau's sonic experiments were based on the relationship between sound velocity and the elasticity of the medium as given by Young's modulus. If a sound wave is propagated along a medium whose transverse dimensions are small compared to the wavelengths utilized, then the following well-known relation holds:

$$E = v^2\rho \qquad (1)$$

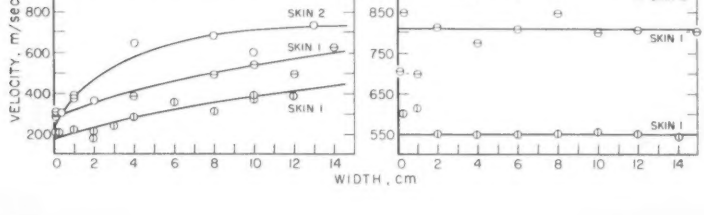
where v is the velocity of sound, ρ is the density of the medium, and E is Young's modulus, the latter being defined as the force per unit cross-sectional area required to produce unit elastic strain. However, if the material produces appreciable acoustic attenuation, as shown by a notable decrease in the amplitude of the sound wave as it travels through the medium, the single relation given above no longer suffices for an accurate determination of the modulus. An additional factor based on a viscosity coefficient must then be applied to the right-hand side of the equation.

In the current investigation, estimates of sound attenuation in leather were obtained by observing on an oscilloscope the decreasing amplitude of a particular section of a 3,000-cps wave train as the transmitter and receiver crystals of the propagation meter were separated. On the basis of these rough measurements, the attenuation for shoe-upper leather was estimated at 0.1 to 0.2 nepers/cm. For purposes of comparison, the attenuation constants were also obtained, under the same conditions of frequency and temperature, for other polymeric materials, with these results:

polyethylene	0. 012 nepers/cm
nylon (undrawn filament)	0. 003
neoprene GN at 6 percent strain	0. 51

It may be seen that the acoustic attenuation in leather lies midway between that of materials with highly crystalline fibers and that of rubberlike materials.

In developing leather test methods, attenuation and frequency are of secondary importance because only relative velocity measurements are required to establish



Graphs of sonic measurements made on sharkskin show how velocity varies with width (at left) if the specimens are cut with their long dimension at 45° to the fiber axes. Such cutting causes sound to travel in zigzag path. Sound speed in specimens cut with their long dimension parallel to one of the fiber axes (right graph) showed no appreciable dependence on width but an increase in speed.

the deviation of a sample from its control. The data of this investigation were therefore studied in terms of the more directly measurable quantity, velocity. Now, the defining equation,

$$E = \frac{\text{stress}}{\text{strain}} = \frac{\text{load}}{\text{elongation}},$$

makes clear the direct relation holding between E and the resistance to elongation. In the light of this relation, eq (1) may be interpreted as saying that the speed of sound through a medium such as leather is greatest in the direction that offers the greatest resistance to elongation—that is, along the individual fibers.

In experiments with leather from cattlehide, the speed of propagation of sound varied with the lateral dimension of the specimen, increasing with width up to a certain maximum dependent on the wavelength of the sound. In cattlehide the fibers are oriented at random; consequently, there is no sound path directly along the specimen. That the speed of sound through a material like leather is related to fiber orientation was shown with vegetable-tanned sharkskin. In sharkskin, the fibers occur naturally in a highly oriented basket-weave pattern, the two fiber axes being mutually perpendicular in the plane of the hide. Specimens were cut so that sound could be transmitted either in the direction of a fiber axis or at a 45° angle with the axes. The specimens cut at an angle of 45° with the fiber axes should have sound paths roughly comparable with those existing in cattlehide, and a similar velocity-width relation would be expected. On the other hand, specimens with one set of fibers oriented in the direction of sound propagation should show no velocity decrease when width is decreased, since there is a sound path that goes directly through the specimen. For both types of specimen, experiment conformed to expectation. The 45° cuts showed the same sort of velocity-width relation as did leather, and in parallel cuts the velocity was independent of the width within experimental error. The velocity of parallel propagation was also observed to be greater than the maximum velocity in the oblique direction.

Additional evidence that sound propagation follows fiber orientation was obtained from experiments with kangaroo tail tendons. These tendons are composed of collagen fibers highly oriented along a single direction. The speed of propagation through the tendons was approximately 2,000 meters per second, or about three times greater than the speed in cattlehide.

Another study showed that the speed of sound through leather increases with period of aging at 100° C until it reaches a maximum. Therefore, an indication of the quality of a sample of leather may be obtained by comparing the speed of sound through the sample with the maximum speed in a control specimen that has been subjected to aging.

It is thus possible to detect changes in fiber orientation without harming the specimen by comparing sound-velocity measurements caused by strain, aging, and filling. Moreover, there is good correlation between sonic measurements and the results of tensile and breaking elongation tests. The effects of tannage, grease, and moisture can also be demonstrated. Finally, for an inhomogeneous material such as leather, the sonic technique has the distinct advantage of providing a means of following the effects of aging, chemical treatments, and the like on a single specimen.

[1] *For further technical details see* Studies on leather by means of a sonic technique, *by J. R. Kanagy and M. Robinson, J. Am. Leather Chemists' Assoc.* (in press).

Improvements in Standard Frequencies Broadcast by Radio Stations WWV and WWVH

IMPROVEMENTS have been made in the technical radio broadcast services provided by stations WWV, near Washington, D. C., and WWVH in Hawaii. Users may now make a better assessment of high-precision oscillators and clocks without waiting for correction data.

Broadcasts have been increased in accuracy from 1 part in 50 million to 1 part in 100 million. Also, broadcast frequencies at WWV are now normally held within plus or minus 1 part in a billion of the Bureau's primary standard of frequency. This is done if necessary by making daily adjustments at 1900 UT. The primary standard, which is constant to 1 part in a billion, is derived immediately from standard quartz crystal clocks which are evaluated over long intervals with reference to Standard Time from the U. S. Naval Observatory.

Time signals from WWV are maintained in close agreement with a new uniform time, called UT 2, determined by the U. S. Naval Observatory. This is done by occasional step adjustments in time of precisely plus or minus 20 milliseconds. Adjustments may be necessary several times a year. When required they are made on Wednesdays at 1900 UT simultaneously at WWV and WWVH.

The broadcast frequency from WWVH is now normally held within five parts in a billion of the primary standard. Adjustments are made, if necessary, at the station each day during the interval 1900 to 1935 UT.

During this same interval, the time signals from WWVH are adjusted, if necessary, so as to commence simultaneously with those from WWV, within plus or minus 500 microseconds.

Final corrections to the broadcast frequencies are available as before on a quarterly basis from the NBS Boulder Laboratories, Boulder, Colorado. Final corrections to the time signals as broadcast are determined

and published on a weekly basis by the U. S. Naval Observatory, Washington 25, D. C.

The same six technical radio services are given continuously by the stations; they are: Standard radio frequencies, standard audiofrequencies, standard time intervals, standard musical pitch, time signals, and radio propagation forecasts. The radio carrier frequencies (2.5, 5, 10, 15, 20, and 25 Mc) are unchanged.

Recent additional modifications in the broadcast program are as follows:

(1) At WWV and WWVH, the time interval for the tones 440 or 600 cps is shortened from 4 min to 3 min. This gives longer intervals, free from modulation, which are useful in the assessment of high-precision frequency standards.

(2) At WWV, the tones 440 or 600 cps are interrupted precisely 40 milliseconds each second except at the beginning and end of each 3-min tone interval. The time pulse commences precisely 10 milliseconds after commencement of the 40-millisecond interruption. An additional pulse, 0.1 sec later, is transmitted to identify the beginning of each minute. As before, no pulse is transmitted at the beginning of the last second of each minute.

(3) WWV is off the air for approximately 4 min each hour. The silent period commences at 45 min, plus or minus 15 sec, after each hour.

(4) At WWV the tone frequency 440 or 600 cps, except on 25 Mc, is experimentally operated as a single upper sideband with full carrier. Power output from the sideband transmitter is about one-third the carrier power. Single sideband tone on 25 Mc may be added at a later date. Other signals (announcements and seconds pulses) remain at 100 percent amplitude modulation, double sideband.

(5) At WWVH the wave form of the seconds pulse now consists of 6 cycles at 1.200 cps tone.

(6) At WWVH the radio propagation forecasts at 9 and 39 min past each hour are for the North Pacific area. Those from WWV at 19½ and 49½ min past each hour are unchanged; they are for the North Atlantic area.

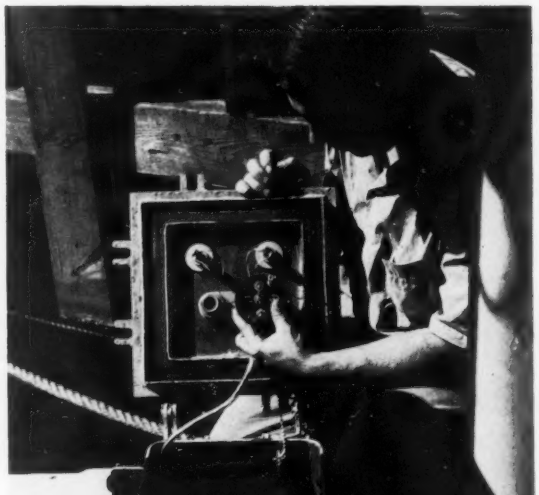
All inquiries concerning the technical radio broadcast services should be addressed to National Bureau of Standards, Boulder Laboratories, Boulder, Colorado.

An Ocean-Based Automatic Weather Station

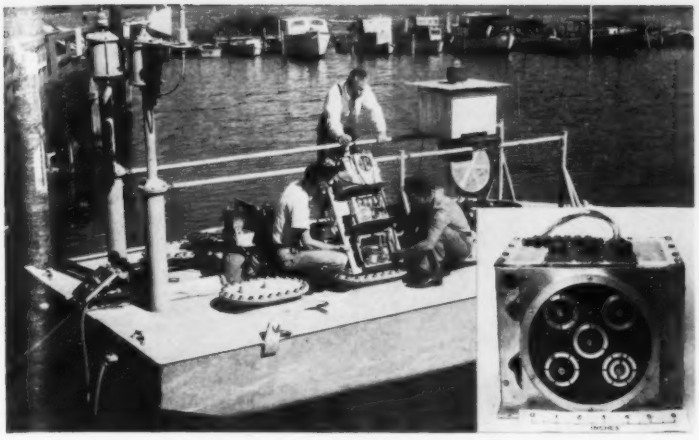
THE BUREAU has developed a prototype marine weather station that automatically reports local weather data by radio. Incorporated in a buoy, the unit can be anchored in remote locations and left unattended for periods up to six months. At regular intervals throughout the day, the station broadcasts in code the air temperature, water temperature, barometric pressure, and wind speed and direction. Preliminary tests in Chesapeake Bay show that the station has a radio range in excess of 800 miles. The equipment was developed by P. D. Lowell, W. Hakkarinen, and L. M. Allison of the Bureau's electronic instrumentation laboratory for the Navy Bureau of Aeronautics.

At the present time the gathering of comprehensive weather data from many ocean areas outside of regular shipping lanes is haphazard and limited. Both military and civilian authorities would be better able to predict weather conditions if they received continuous weather reports from a much wider area. If a series of stations similar to the Bureau's prototype station were placed over wide areas of the Pacific Ocean, for example, they could give operations officers and meteorologists frequent reports making possible a complete weather picture for the entire ocean. If moored in certain areas of the Caribbean, these stations might also give warning of hurricanes as they begin to form.

The automatic station translates information from each of five weather-sensing elements into three-letter groups in continental code and transmits the coded signals on a pulse-modulated 6-megacycles per second carrier frequency. These signals can be received on standard communications receivers and compared with a decoding table which gives numerical values for each of the meteorological variables measured. A single transmission takes 3 minutes. During this interval six items of information are broadcast. The first transmission is a three-letter signal identifying the station. Coded transmissions follow containing information on (1) air temperature between −25° and +110° F, (2) water temperature between 15° and 90° F, (3) barometric pressure between 950 and 1,050



Part of the control equipment for the marine weather station. At regular intervals throughout the day the station broadcasts in code the air temperature, water temperature, barometric pressure, and wind speed and direction.



The marine weather station can be anchored in remote locations and left unattended for periods up to 6 months. The four wells hold all the electronic equipment. Insert shows a closer view of one of the control elements. Circular switches in this timer select elements whose data is to be transmitted.

millibars, (4) wind speed from 0 to 68 knots, and (5) wind direction oriented from magnetic north.

The vessel that carries the weather-sensing and radio transmitting equipment was designed by the David Taylor Model Basin and is 20 ft long and 10 ft wide. It is constructed of aluminum and other nonmagnetic alloys to avoid undesirable effects on the compass. The vessel can be anchored in waters as deep as 3,600 ft. Two masts and four watertight wells extending below the boat deck hold all the electronic and meteorological equipment assembled in compact, shock-mounted units. Each unit may be replaced independently of the others.

The weather-sensing elements convert variations of water surface conditions into variations of resistance for measurement by a motor-driven self-balancing bridge circuit. The air- and water-temperature sensing devices are simple thermistors. A precision barometer measures air pressure. This barometer is so modified that a slave needle rides above a resistance strip and is clamped to the strip at the time of measurement. An especially rugged three-cup anemometer drives a small magnetic generator whose output is applied to the grid of a vacuum tube. Plate resistance of the tube is measured in the bridge. The wind vane is connected to a selsyn transmitter and receiver circuit activating a servo system. The servo positions a magnetic compass synchronously with the wind vane. Mounted on gimbals, the compass has a sleeve needle and clamping system that gives resistance values corresponding to the wind direction relative to magnetic north.

Primary power comes from 180 4FH dry cells connected in series-parallel to give 13.5 v at 15 amp. A rotary converter changes the low-voltage dc to 120 v at 60 cps to operate the power supply for the electronic components. In future models of the boat stations, a gasoline-powered generator and storage battery will replace the dry battery supply.

At some predetermined time after a suitable warmup period, a master timer closes the contacts that feed power to all circuits. A chronometer watch, rewound by motor at the time of station activity to ensure accuracy over extended periods of time, furnishes reliable master control. When the power is applied, a program timer consisting of a number of circular switches driven by a constant speed motor inserts a precision resistance into the self-balancing bridge. As the first radio signal to be transmitted is the station identifying signal, this precision resistor, instead of one of the weather variable resistances, is the first contacted in the program timer. The resistance of a helical potentiometer at the bridge balance point matches this resistance. On the same shaft with the potentiometer is a rotary code selector switch that selects letters on a code generator; these letters then correspond to the value of the resistor inserted into the bridge. The code generator, a drum made up of eight metal rings insulated from each other, has the code characters machined in relief on the inner circumference of the rings. A comb-type brush contactor sweeps inside the drum, contacting the raised segments. The raised code characters designated by the selector switch, when in contact with the comb, close a keying relay circuit. Then, over a 20-sec interval, the transmitter is keyed in code with a three-letter group. Sending speed can be controlled by the comb speed, and a rate of five to seven signal repetitions during the 20-sec interval permits even inexperienced operators sufficient time to copy the signal.

During the interval when the station is identifying itself, a resistance determined by the first of the five weather variables is connected to the bridge circuit. At the end of the identification interval, a 10-sec delay ensues while bridge balance and code selection occur. Then the first of the weather data is broadcast. While this signal is being transmitted, the next weather variable is selected and then transmitted at the end of the first weather signal. The remaining variables are transmitted in like manner. Altogether, the 3-minute transmission period contains six transmission intervals of 20 sec duration, each preceded by 10-sec balancing intervals. At the conclusion of the transmission period, the master timer contacts are broken to remove power from the equipment until time for the next period of station activity.

I Often Say . . .

THAT WHEN YOU CAN MEASURE YOU
EXPRESS IT IN NUMBERS, YOU SOME
YOU CANNOT MEASURE IT, YOU CAN
YOUR KNOWLEDGE IS OF A MEAGRE AND
MAY BE THE BEGINNING OF KNOWLEDGE.
IN YOUR THOUGHTS, ADVANCE THE STAGE
THE MATTER MAY BE.

GUEST WEEK 1956

Recentific

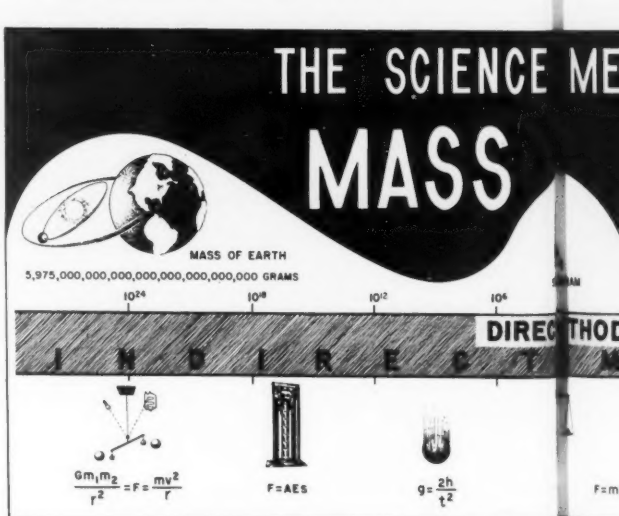
PLANS for a more accurate redetermination of the acceleration of gravity were announced to visitors attending Guest Week at the National Bureau of Standards January 23–27. The exacting physical measurements required for this determination set the theme of the Guest Week program, which centered about the science of measurement and stressed its significance to scientific and technological progress.

Over 800 guests, leaders from science, industry, education, and Government, attended Guest Week at the invitation of Secretary of Commerce Sinclair Weeks and Dr. Allen V. Astin, Director of the Bureau. The visitors were taken on guided tours involving the work of 14 laboratories. Included were an exhibition of the new forward scatter method for broadcasting radio and television signals,[1] a recently developed analog computer for instantaneous determination of radioactive fallout patterns, an automatic hurricane weather station,[2] and a freezing point oven for maintaining crystal oscillators at a very constant temperature.

Also on exhibit were three recent developments utilizing the physical sciences for medical and dental applications. These were a panoramic X-ray machine[3] that rapidly takes a single X-ray picture of the entire dental arch, a cardiographic jerkmeter[4] for studying the action of the human heart, and a physiological monitor[5] for measuring continuously the physical condition of a patient under anesthetic.

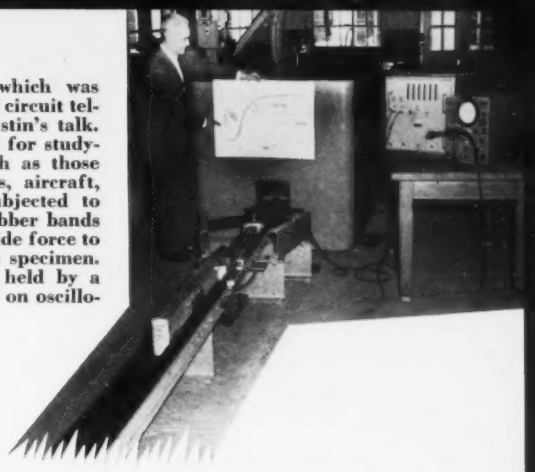
Before beginning their tour, guests assembled in the engineering mechanics laboratory, a three-story room containing large machines for calibrating force measuring devices and testing materials and structures.

Above, NBS Director A. V. Astin presents a lecture-dem on the drop (below) which showed how Bureau mass and forements e electron. Between these extremes are the 10-million-po exerte lower left) and the relatively small force encountered rrent ba are based on the national standard of mass, a kilogram. In ma to know very accurately the constant *g*, which defines relation to redetermine *g* by the falling body method (left of oil balan used to derive the absolute ampere from the primary of length by an electromagnet (right of current balance) pro ans for current balance, to the standard kilogram. More accu ination sulted from magnetic resonance absorption measureme right). mining the universal constant of gravity *G*.



MEASURE YOU ARE SPEAKING ABOUT, AND
RS, YOU SOMETHING ABOUT IT; BUT WHEN
E IT, YOU CANNOT EXPRESS IT IN NUMBERS,
S OF A MEAGER AND UNSATISFACTORY KIND; IT
ING KNOWLEDGE, BUT YOU HAVE SCARCELY,
ADVANCED THE STAGE OF SCIENCE, WHATEVER

—Lord Kelvin
1883.

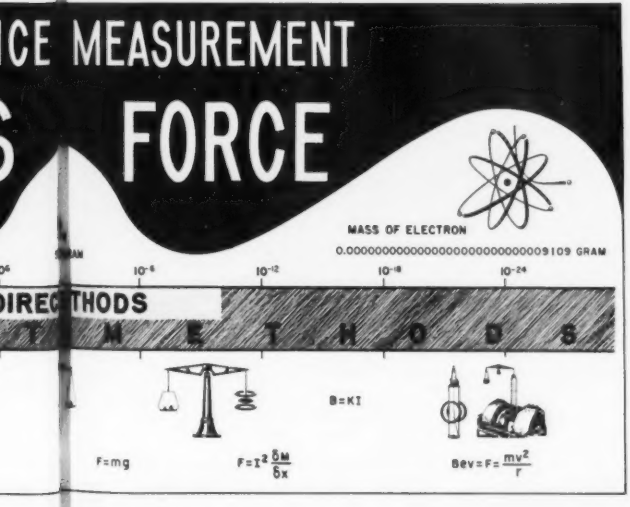


"Sling shot" machine which was demonstrated over closed circuit television as part of Dr. Astin's talk. The device was designed for studying transient forces such as those experienced in buildings, aircraft, and other structures subjected to sudden loads. Large rubber bands at rear end of track provide force to send a projectile toward specimen. Strain versus time plot held by a staff member is obtained on oscilloscope at right.

6

ecentific Developments Exhibited

**re-demon the science of measurement. He spoke before a back-
nd forements extend from the mass of the earth to the mass of the
llion-pot exerted by the Bureau's giant testing machine (2d from
nteredurrent balance. Yet all such measurements in this country
logram. In making mass and force measurements it is important
efines relationship between mass and force. The Bureau plans
ft of coil balance). The current balance (right of balance) is
mary of length, mass, and time. Deflection of an electron beam
) proveans for relating the mass of the electron, through the
e accurminations of the electron charge-to-mass ratio have re-
uremeright). Depicted at far lower left is the method for deter-**



There they witnessed a lecture-demonstration on the science of measurement by Dr. Astin. Because the science of measurement is so broad, Dr. Astin limited his discussion largely to measurements of two quantities which are of great importance to science and engineering—namely, mass and force. Illustrating his remarks with equipment in actual operation, he discussed the Bureau's work in making measurements over the vast range extending from the mass of the electron (9.109×10^{-28} gram) to the mass of the earth (5.975×10^{27} grams). He pointed out that only over a limited portion of this range is it possible to measure mass directly by means of balances. To measure either very large or very small masses, indirect techniques must be devised using electronics, optics, sound, atomic science, and other branches of physics and engineering. The guests were shown the national standards of mass and length—the meter bar and the kilogram—which, together with the rotating earth as a standard of time, constitute the three primary standards basic to all types of scientific measurements.

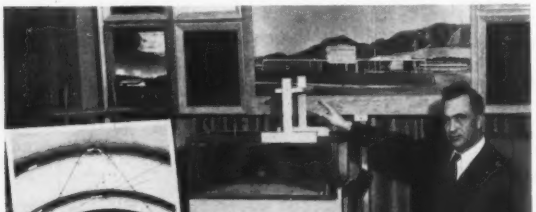
Dr. Astin brought out the importance of g, the acceleration of gravity, in establishing a relationship between mass and force. A simplified mockup of the method by which the Bureau plans to redetermine g was shown. The experiment will involve measuring the time required for a ball to fall freely in a vacuum. In 1936 the Bureau measured g with an accuracy of three parts in a million by means of the reversible pendulum. Because of the advances that have since occurred in electronic timing and optical measuring techniques, it is believed that greater accuracy can now be achieved by the falling body method. In the final experiment on g, time and length measurements will be attempted to an accuracy of 3 parts in 10 million. If this is successful, the final result for g should have the desired accuracy—1 part in a million. The constant g is also important in the earth sciences—geology and geophysics—and in meteorological studies of the atmosphere.

Dr. Astin's discussion of the measurement of very large forces was illustrated by the calibration of a 1,000,000-lb dynamometer in the 10,000,000-lb testing machine, believed to be the most powerful of its kind in the world. Using the principle of the wire strain

gage, the Bureau has developed compression dynamometers [6] capable of measuring forces up to 3,000,000 lb, for use in calibrating multimillion-pound testing machines throughout the country. Previously the greatest load that could be accurately measured was approximately 2,500,000 lb, and this required the simultaneous use of several high-capacity proving rings. With the new dynamometers, calibrations can be performed more quickly and at considerably less cost.

Very small masses such as that of the electron are measured indirectly by making use of electric and magnetic forces. The guests were shown by actual demonstration how the Bureau derives the absolute electrical units from the basic standards of length, mass, and time. The demonstration experiment was then extended to give the mass of the electron in terms of these basic standards.

Derivation of the electrical units from the three primary standards was illustrated with the Bureau's current balance. This apparatus measures a current in absolute amperes by determining the mechanical force between two parts of the circuit in which it flows. The force between coils carrying the current is measured with a sensitive balance. From the value of this force and the mechanical dimensions of the coils, the absolute value of the ampere is computed in terms of the fundamental standards of length, mass, and time. The absolute ohm is defined in terms of the primary standards by another experiment involving mechanical measurements; and from these two derived units, the Bureau has set up standards for all other electrical quantities—such as voltage, power, and energy—in use today.



The Bureau's Boulder laboratories provided a demonstration of the principles of radio propagation by forward scatter techniques for Guest Week visitors. Equipment for demonstration by optical analogy is in center. Chart at left also illustrates forward scatter, a new transmission technique being studied by radio laboratory scientists.

The guests were then shown how the current measured by the current balance can be used to deflect a stream of electrons. Since the amount of the deflection depends on the charge to mass ratio (e/m) of the electron and on the current in the deflecting coil, this experiment provides a means for relating the mass of the electron, through the current balance, to the standard kilogram.

To meet the needs of modern atomic and nuclear physics, the Bureau has developed a more accurate method for determining the gyromagnetic ratio of the proton which incorporates a number of new developments in radio, electronics, and atomic physics. A mockup of the apparatus was shown to the guests. The method [7] involves measurement of the magnetic field and radiofrequency required for magnetic resonance absorption in a proton sample. This procedure made possible a more accurate value of e/m than ever before obtained. Further increase in the accuracy of the method depends upon the attainment of a more accurate value for g, which the Bureau hopes to provide.

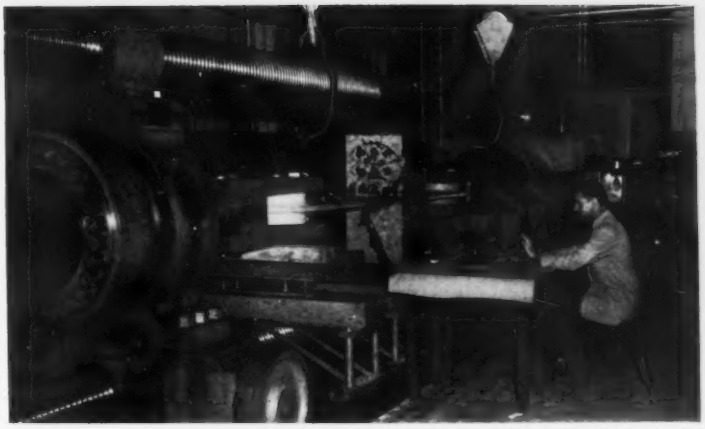
After the lecture demonstration, the guests were taken to other NBS laboratories to see demonstrations of work in the fields described below.

Electronics in Measurement. The phenomenal growth of the electronics industry is due only in part to the expanding consumer use of a wide variety of electronic devices such as television, radio, and HiFi. Modern weapons, many modern factories (particulary where automation is under way), and modern science are becoming increasingly dependent on electronics. This dependence is intimately related to the usefulness of electronics for making physical measurements. Electronic techniques are especially helpful in solving measurement problems where very high speeds, extremely small energies, or limited accessibility are important.

In addition to basic electronic research, the Bureau's electronic laboratories are frequently asked to apply electronic measurement techniques to new or special problems confronting other Bureau research laboratories and other Government agencies. One problem recurring in different engineering fields, for example, has been the measurement of small distances or clearances in inaccessible places. A typical example is measuring clearances between moving and stationary blades in ship steam turbines. In solving this, an electronic technique was developed that has been successfully applied to a number of other problems.

Lenses and Airplane Cameras for Accurate Mapping. Measurements based on aerial photographs are used in both planimetric and topographic mapping. Such maps are essential to the operations of the Armed Forces, to the numerous civilian agencies such as the Coast and Geodetic Survey and the Conservation Service, to private enterprise such as the lumber and oil industries, and to the various agencies of State and local governments.

The first step in making an aerial map is photographing the desired area. For maximum usefulness, these photographs must have at least two important qualities. They must accurately reproduce the distance relationships between objects in the scene, and they must provide as much detailed information as practicable about the various objects. These qualities can be ensured by carefully analyzing the photographic lenses that are used in photogrammetric mapping cameras.



Also shown on closed circuit television was this demonstration of welded ship plate being deformed under load in a 2,300,000-pound testing machine. Wire strain gages located at various points give data on specimen distortion. Unexpected failures of welded ships have pointed to need for such work.

The NBS precision lens testing camera and camera calibrator accomplishes this by making precise determinations of the optical characteristics of aerial camera lenses. These factors—focal length, distortion, and resolving power—control such qualities as scale size, true image position, and picture clarity.

The Application of High-Speed Electronic Computers. The interpretation of many scientific experiments and the solution of engineering and research problems often require extensive calculations. In fact some problems are so large that they can be efficiently performed only on high-speed computers. The Bureau's computer, SEAC, has played a pioneering role in solving problems that previously were either entirely beyond solution or were too laborious and time consuming to attack by hand and other methods. On a round-the-clock schedule, SEAC is primarily employed in solving measurement problems that arise at NBS or elsewhere in the Government.

A typical recent application of SEAC, of fundamental scientific importance, was its use in performing the extensive statistical calculations necessary to interpret measurements arising in a redetermination of the velocity of light—a physical constant of basic importance to science. Other problems have dealt with distribution of forces in an airplane during landing impact, nuclear reactor design, and flutter of delta wings for supersonic aircraft. Also, Bureau scientists engage in computer design and engineering, and study data processing problems of interest to Government.

Analog Computers: Computing Radioactive Fallout. Wherever the constants of a complex physical problem can be expressed by empirical curves or written into mathematical equations, an analog computer is usually the fastest method of obtaining an approximate solution. The analog computer is one of the older calculating devices. The slide rule is, for example, a small-scale computer.

The Bureau's computer represents physical quantities by electrical voltages, and their interrelation is fixed by setting dials and plugging cords into a separable problem board. The analog can add, subtract, multiply, and divide. It can also solve sets of algebraic equations, integrate ordinary and partial differential equations, and simulate a variety of nonlinear phenomena.

Among the problems to which the Bureau is currently applying analog techniques is the geographic pattern of radioactive fallout from a nuclear explosion. Other problems solved by such machines are the simulation of the motion of an airplane or guided missile, the acceleration of a jet engine, the conduction of heat through a wall, the comparison of seismometer designs, and the partial pressures of the gases in a flame.

Precision equipment for calibrating aerial camera lenses was shown to guests in the optical instruments laboratory. Bank of collimators at extreme right provides series of "distant objects." Test patterns of these objects are obtained on a photographic plate.

Another device first shown at Guest Week was the analog computer for calculating radioactive fallout patterns from a nuclear detonation. The device was suggested by the Weather Bureau and sponsored by the Atomic Energy Commission. A fallout pattern is shown on the oscilloscope screen at left. Pattern is calculated in 20th second after data giving details of bomb and wind velocities and directions are set into the computer.

Temperature Measurements in Jet Engine Research. The search for increased thrust or power from jet engines leads to hotter engine components and burning gases. However, instruments currently used in temperature measurement and control are becoming inadequate because they are unable to withstand temperatures that may be well above 3,000° F—considerably higher than the melting point of steel. Two problems thus are presented: first, developing a satisfactory instrument and second, calibrating the chosen instrument.

One solution to the first problem lies in using a thermocouple in which one wire is the highly refractory rare metal, iridium; the other wire is an alloy of iridium and rhodium. These materials were selected after a series of comparative tests on several alloys.

Because conventional furnace materials will melt at the high temperatures that are required, the second problem must be solved by special techniques. This involves using a hollow iridium enclosure that is heated in a high-frequency induction furnace. The thermocouple measuring junctions are inserted in the enclosure and their readings are compared with temperature readings taken by special laboratory procedures.

Engineering Materials at Very Low Temperatures. Low-temperature liquefied gases—oxygen, hydrogen, nitrogen, and helium—are finding increased application in industry and national defense. This necessitates larger, more convenient, and less hazardous equipment for producing and handling these liquids. Thus many new and highly complex engineering problems have arisen and much remains to be learned about the behavior of engineering materials at low temperatures. At liquid-hydrogen temperatures (about −420° F) normally trustworthy construction steels become brittle, rubbers lose elasticity, and the mechanical properties of plastics are greatly altered.

The NBS Cryogenic Engineering Laboratory conducts a twofold program. It investigates structural and other engineering properties of matter at low temperatures, providing data needed to develop more satisfactory materials and equipment. The laboratory also produces large quantities of liquefied gases and develops better techniques for their production. An important process presently under investigation promises a less costly source of heavy water, an expensive ingredient vital to the operation of some nuclear power reactors.

New Alloy Systems. Modern technology demands better materials to meet an ever increasing variety of applications. For example, metals are needed that will remain useful at high temperatures or have unusual stability. In satisfying these needs metallurgists must continually develop new alloys.

To guide this work they must have fundamental information about the properties of metallic systems in combination. Such information, gained from basic research, is expressed in the form of specialized charts called constitution diagrams. Establishing these constitution diagrams is one of the important activities of the Bureau's metallurgy laboratories.

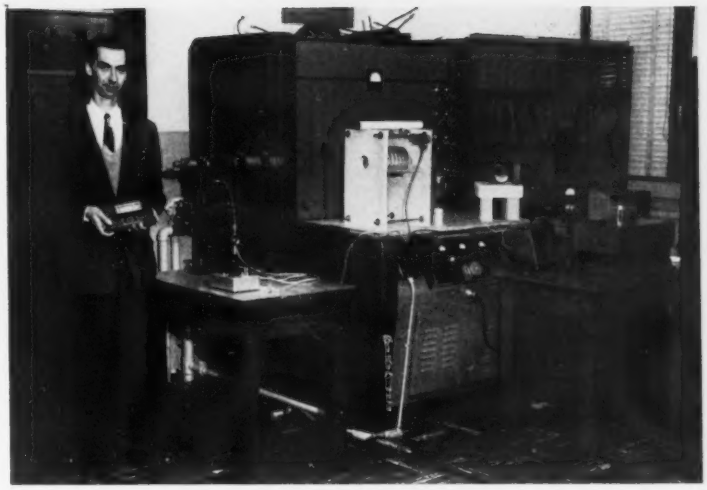
Investigating alloy systems involves the preparation of many samples of different composition. Using various methods the metallurgist then determines the temperatures at which physical and structural properties change. To effectively determine these properties, studies must be made during both slow and rapid temperature changes.

An example of how the rate of temperature change affects an alloy's properties is best found in many steels. In these alloys, slow cooling results in a soft, relatively weak metal while rapid cooling by quenching gives a hard strong metal.

Standard Fuels for Knock Rating. An important factor in the "matching" of engines and fuels is the octane number. Because of the trend toward higher-compression engines in the automotive industry, as well as aviation requirements, high octane numbers are increasingly important.

The National Standards for measuring octane number are two hydrocarbons (normal heptane and iso-octane) which were synthesized and purified to a high degree in NBS laboratories. Ultimately, the quality of all the gasoline sold, at the rate of about 6 million gallons per hour, is referred to the National Standards.

As the continuing development of engines and fuels brings new problems, researches are conducted to im-



Guests visiting the temperature measurements laboratory were shown a method being developed for calibrating iridium versus iridium-rhodium thermocouples. These devices must be usable above 3,000° F. for jet engines. Thermocouple measuring junctions are inserted in a blackbody within an induction furnace (center), and their electromotive force readings are compared with temperatures determined by an optical pyrometer (left).

prove the precision of measurement, to raise the quality of the fuel standards, and to study the mechanism of fuel combustion as well as the effects of such variables as altitude, temperature, and humidity.

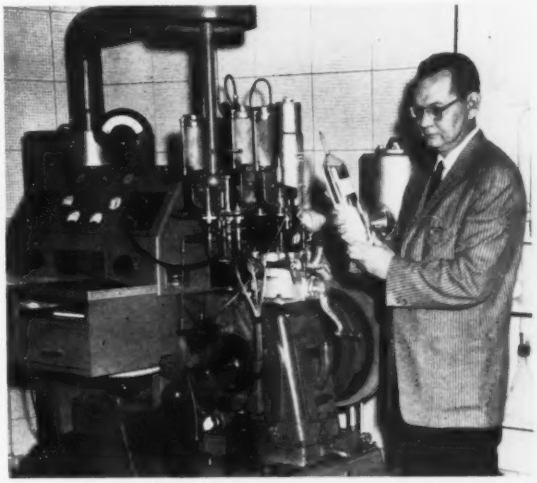
The Bureau has played an important part in the study of the relationship between the knocking characteristics of gasoline constituents and their molecular structure. These studies provide a background of information useful in maintaining the standards.

Radioactivity: Measurement and Standards. With the increasing need for radioactive materials in research, medicine, and industry, standards of artificial radioactivity are as essential now as radium standards were 40 years ago. An ever-growing demand for increased accuracy has accompanied the improvements of the measurement techniques available to the individual research worker. To meet this demand the Bureau has had to develop improved measurement methods for radioactive materials.

The Bureau's program has two prime objectives—the first is designed to meet the expanding need for radioactivity standards and the second to develop the more precise measurement methods that will assure uniform results by all users. Of the Bureau's six related radioactivity facilities, the newest is the radiochemistry laboratory. These facilities now provide approximately 57 different radioactivity standards. To assist in efforts toward increased accuracy and studies of the basic properties of radioactivity, the use and development of improved measurement techniques are required. For example, a radiation balance has been developed which determines the strength of a radioactive source by measuring the rate of energy emission in the form of heat.

Molecular Properties of Polymers: Resins, Rubbers, Plastics. The annual value of products manufactured by the textile, paper, plastics, rubber, and leather industries is well over 25 billion dollars. These natural or synthetic polymeric materials are composed of very long chainlike molecules formed by polymerization. Many of their useful properties are related to the size, shape, distribution, and flexibility of the molecules and their interaction with other molecules.

The Bureau investigates polymer formation, constitution, structure, and properties. These studies, all of which involve measurement, advance fundamental knowledge of these important materials. A problem of particular interest is the measurement of molecular weights of high polymers; the same equipment and procedures have been employed to evaluate dextran used as a blood plasma volume expander by the Department of the Army. The efficiency of this material in the body depends on its molecular weight and structure.



Visitors were shown this specially designed test engine for knock-rating motor gasolines. A fuel is rated by comparing its knock intensity reading, given by the test engine, with readings for the Bureau's two knock rating standards, normal heptane and iso-octane. A staff member holds a sample of one of the standards.

Guest week marked the first showing of the panoramic dental X-ray machine. Developed in cooperation with the Air Force, this machine takes a single panoramic X-ray picture of the entire dental arch in about 40 sec. Present techniques now require about 20 min for a full-mouth survey. The armed forces are particularly interested in the new machine for making dental surveys of personnel.

Suitable test methods have been devised to characterize the plasma expanders and to compare their properties as determined in the laboratory with the results obtained in clinical tests.

Purity of Materials: Titanium Process Control. The properties and usefulness of titanium, a "new" metal of great industrial promise, are very greatly affected by the nature and amount of its impurities. In producing titanium, control of the purity of the metal begins with the control of the purity of its parent material, titanium tetrachloride.

The Bureau has developed a procedure for measuring the purity of titanium tetrachloride, a waterlike liquid that freezes at −24.1° C. The process requires precise observations of the small changes in temperature that occur during freezing.

During Guest Week there was a special exhibit on physical science applications to medicine and dentistry. The panoramic dental X-ray, the physiological monitor, and the cardiographic jerkmeter (above) were exhibited. The jerkmeter is essentially a piezoelectric accelerometer which measures the third-time derivative (defined as *jerk*) of the displacement of a reclining patient. This motion is intimately related to heart function.

For a relatively impure sample, for example, the measured change in temperature might be as much as 0.10° C, corresponding to about 0.20 percent of impurity in the sample. Actually, changes in temperature from 10- to 100-fold smaller are frequently observed and can be measured accurately. These smaller temperature changes represent correspondingly smaller amounts of impurity.

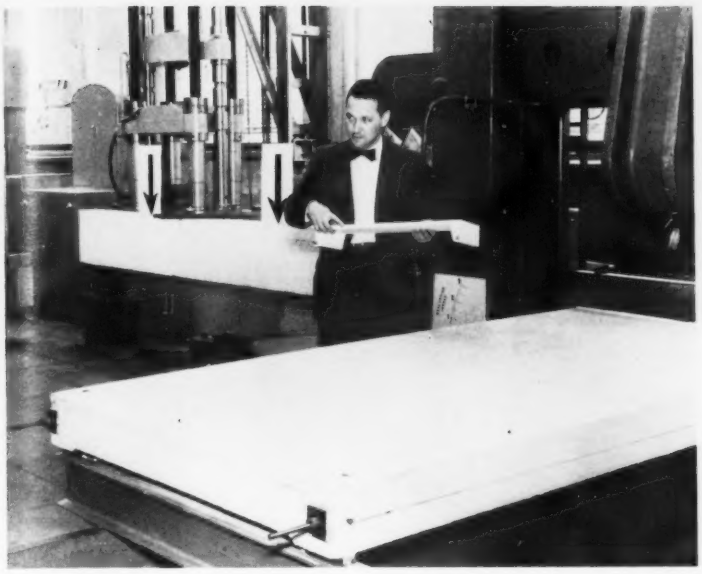
The procedure is one in which NBS has done much of the original development and refinement. It is applicable to many types of substances and is in extensive industrial use, including at least one titanium plant.

Properties of Materials at High Temperatures. One of the major bottlenecks in the further development of jet planes, rockets, guided missiles, and nuclear power plants is the lack of materials that will stand up under the terrific heats generated. Thus materials that will withstand temperatures above 3,000° F are urgently needed. The immediate problem is not necessarily one of developing new refractory materials. Rather it is more a need for accumulating fundamental data on the high-temperature properties and behavior of existing materials.

In general, a study of high-temperature systems immediately raises a host of problems not encountered in ordinary ranges. Unpredictable, complex molecules may be formed. Often complete reversal of a compound's low-temperature properties are encountered at high temperatures. Impurities, even in the minutest amounts, can have a profound effect on a material at extreme heats.

To investigate these various properties the Bureau has a special laboratory where measurement techniques are in the process of being developed and applied. A recent addition to this laboratory is a solar furnace that can produce temperatures up to 7,000° F—two-thirds as hot as the surface of the sun.

Structural Elements: Their Strength and Performance. People are so accustomed to living and working in buildings, that few give thought to the safety of the structure they are occupying. That they are able to do so is a tribute to the skill and integrity of designers, engineers, and builders.



The building technology laboratories exhibited some of their recent work during Guest Week. Shown is a prestressed, precast concrete roof slab under load in a high-capacity testing machine. A model showing the thin shell construction is in the speaker's hand. In background is an exhibit of the cracking of a conventional reinforced concrete beam under load.

However, in order to design safe and economical structures, architects and engineers must know the properties of building materials and of structural elements. Much of such knowledge is obtained in the Bureau's structural engineering laboratories by actual tests of components such as beams, slabs, walls, and columns, and of assemblies of such components.

The information thus obtained provides Government and industry the means of establishing satisfactory specification and code requirements governing the performance of structural elements under various service conditions.

In evaluating the performance of structural elements, procedures must be followed that yield reproducible and accurate data.

One phase of the work in the structural engineering laboratories deals with the development of procedures in order to perfect existing test methods and to devise new techniques and methods of evaluating building construction.

Forward Scatter of Radio Waves: A New Means of Communication. Forward scatter—a recently discovered mode of radio propagation—promises to extend greatly the limits of long-distance communication. Through application of scatter propagation, new frequency channels can be opened, new path lengths utilized, and reliable service provided far beyond the normal line-of-sight limit. Both industry and the armed services anticipate savings through elimination of many relay stations. For more than 5 years, forward scatter has been intensively investigated at the Bureau's Central Radio Propagation Laboratory (CRPL), Boulder, Colorado.

Since World War II, the increasing use of the radio spectrum (including television and radar) has created a growing need for information on radio propagation. Because the world is the laboratory of the radio scientist, CRPL maintains a worldwide chain of stations and cooperating laboratories. Their work aids global aviation, all-weather shipping and harbor control, and world communications.

In addition to radio propagation studies, CRPL maintains the national primary frequency standard and primary standards for electrical quantities at radio frequencies. These standards and associated research are essential to scientific and industrial applications of radio.

[1] Forward scatter of radio waves, *NBS Tech. News Bull.* **40,** *8 and 24 (Jan. and Feb. 1956).*
[2] A free-floating automatic weather station, *ibid.* **36,** *36 (March 1952).*
[3] NBS-AF panoramic X-ray machine, *ibid.* **40,** 1 *(Jan. 1956).*
[4] A cardiographic jerkmeter, *ibid.* **39,** *161 (Dec. 1955).*
[5] NBS physiological monitor, *ibid.* **38,** *109 (Aug. 1954).*
[6] High-capacity load calibrating devices, *ibid.* **37,** *136 (Sept. 1953). See also* The application of resistance wire strain gages to high-capacity load calibrating devices, *by D. R. Tate, Symposium on wire strain gages, NBS Circular 528, p. 121 (1954).*
[7] Magnetic moment of the proton, *NBS Tech. News Bull.* **33,** *57 (May 1949).*

Publications of the National Bureau of Standards

Journal of Research of the National Bureau of Standards, volume **56,** No. 2, February 1956 (RP2648 to RP2655 incl.). Annual subscription $4.00.

Technical News Bulletin, volume **40,** No. 2, February 1956. 10 cents. Annual subscription $1.00.

Basic Radio Propagation Predictions for May 1956. Three months in advance. CRPL 138. Issued February 1956. 10 cents. Annual subscription $1.00.

UNITED STATES
GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON 25, D. C.

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, $300
(GPO)

TECHNICAL NEWS BULLETIN

U. S. DEPARTMENT OF COMMERCE
SINCLAIR WEEKS, *Secretary*
NATIONAL BUREAU OF STANDARDS
A. V. ASTIN, *Director*

March 1956 **Issued Monthly** **Vol. 40, No. 3**

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price, domestic, $1.00 a year; 35 cents additional for foreign mailing; single copy, 10 cents. The printing of this publication has been approved by the Director of the Bureau of the Budget, March 6, 1953.

Contents

	Page
Interconnection of electronic computers	33
A sonic technique for testing leather	35
Improvements in standard frequencies broadcast by stations WWV and WWVH	37
An ocean-based automatic weather station	38
Guest Week 1956	40
Publications of the National Bureau of Standards	47

Research Papers

Journal of Research, volume **56,** *number 2, February 1956. Single copies of the Journal vary in price. Single copies of Research Papers appearing in the Journal are not available for sale. The Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., will reprint 100 or more copies of a Research Paper. Request for the purchase price should be mailed promptly to that office.*

RP2648. Residual entropy of linear polymers. H. N. V. Temperley.

RP2649. Molecular weights of thermally degraded polymethyl methacrylate. Victor Hart.

RP2650. Thermal expansion of binary alkaline-earth glasses. Herman F. Shermer.

RP2651. Dielectric relaxation for a three-dimensional rotator in a crystalline field: theory for a general six-site model. Benjamin M. Axilrod.

RP2652. A matrix with real characteristic roots. Karl Goldberg.

RP2653. Reflection and transmission of gamma radiation by barriers: semianalytic Monte Carlo calculation. Martin J. Berger and John Doggett.

RP2654. An examination of the helium vapor pressure scale of temperature using a magnetic thermometer. E. Amblar and R. P. Hudson.

RP2655. New descriptions and analyses of the third and fourth spectra of zirconium, Zr III and Zr IV. C. C. Kiess.

Miscellaneous Publications

M217. Annual report 1955. 55 cents.

Circulars

C562. Bibliography of research on deuterium and tritium compounds 1945 to 1952. Lawrence M. Brown, Abraham S. Friedman, and Charles W. Beckett. 50 cents.

C564. Tables of thermal properties of gases. Joseph Hilsenrath, Charles W. Beckett, William S. Benedict, Lilla Fano, Harold J. Hoge, Joseph F. Masi, Ralph L. Nuttall, Yeram S. Touloukian, Harold W. Woolley. $3.75.

C567. Guide to instrumentation literature. W. G. Brombacher, Julian F. Smith, and Lyman M. Van der Pyl. 75 cents.

Publications in Other Journals

Reference samples of isotopic abundance. Fred L. Mohler. Science (1515 Massachusetts Ave. NW., Washington 5, D. C.) **122,** No. 1364, 334 (Aug. 1955).

Specific heats of collagen and leather. Joseph R. Kanagy. J. Am. Leather Chemists' Assoc. (Dept. of Leather Research, Univ. of Cincinnati, Cincinnati 1, Ohio) **50,** No. 10, 444 (Sept. 1955).

Textiles at the National Bureau of Standards. W. D. Appel. Proc. Am. Assoc. Textile Chemists Colorists (44 E. 23rd St., New York 10, N. Y.) **44,** No. 23, 795 (Nov. 1955).

Ultrasonic switch aids diversity reception. G. Franklin Montgomery. Electronics (330 W. 42d St., New York 36, N. Y.) **28,** 169 (Nov. 1955).

Geometric factors in electrical measurements relating to corrosion and its prevention. W. J. Schwerdtfeger and Irving A. Denison. Corrosion (1601 M & M Building, Houston 2, Texas) **2,** 25 (Oct. 1955).

Compressibility of binary alkali borate and silicate glasses at high pressures. C. E. Weir and L. Shartsis. J. Am. Ceram. Soc. (2525 N. High St., Columbus 2, Ohio) **38,** No. 9, 299 (Sept. 1955).

Mechanisms of alkali-aggregate reaction. Robert G. Pike, Donald Hubbard, and Herbert Insley. J. Am. Concrete Inst. (18263 W. McNichols Rd., Detroit 19, Mich.) **27,** No. 1, 13 (Sept. 1955).

Variability of wool content in part wool blankets. Emanuel Horowitz and W. S. Connor. ASTM Bulletin (1916 Race St., Philadelphia 3, Pa.) No. 208, 42 (Sept. 1955).

Determination of sulfur in rubber vulcanizates. E. W. Zimmerman, V. E. Hart, and Emanuel Horowitz. Anal. Chem. (1155 16th St. NW., Washington 6, D. C.) **27,** No. 10, 1606 (Oct. 1955).

Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (foreign postage, one-third additional). Reprints from outside journals are not available from the National Bureau of Standards but can often be obtained from the publishers.

U. S. GOVERNMENT PRINTING OFFICE: 1956